



**Barcelona
Supercomputing
Center**
Centro Nacional de Supercomputación



**EXCELENCIA
SEVERO
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Quality Assessment of Decadal Climate Predictions with EC - Earth

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AMS Boston

CMIP6 Model and Full-Field Initialization

Decadal Hindcasts (DCPP-A)

- yearly start dates
- starting 1st Nov
- 1960-2018
- 10 members



EC-Earth 3.3

- Atmosphere: IFS, T255L91
- Ocean: NEMO, ORCA1L75
- Sea ice: LIM 3
- + OASIS coupler

ATM:

Interpolated to
model grid with
OpenIFS

LAND:

Offline land-surface simulation with
near-surface meteorology and corrected
fluxes from ERA-Interim

Atmosphere
reanalysis
(ERA 40 + Interim)

Land reanalysis
(ERA-Land)

Ocean reanalysis
(ORAS4)

Sea Ice
reanalysis

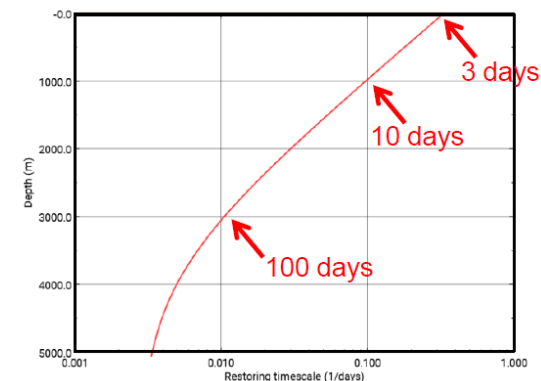
OCE+ SI:

Historical reconstruction with NEMO-LIM stand
alone, forced with DFS/ERA-Interim fluxes, and
nudged globally towards 3D T and S from ORAS4

Default surface
restoring coefficients

$$\gamma_T = -40 \text{ W/m}^2/\text{K}$$
$$\gamma_s = -150 \text{ kg/m}^2/\text{s/psu}$$

Default 3D restoring timescales



Skill Assessment – Surface Temperature – Year 1

Anomaly Correlation Coefficient

Combined surface temperature:

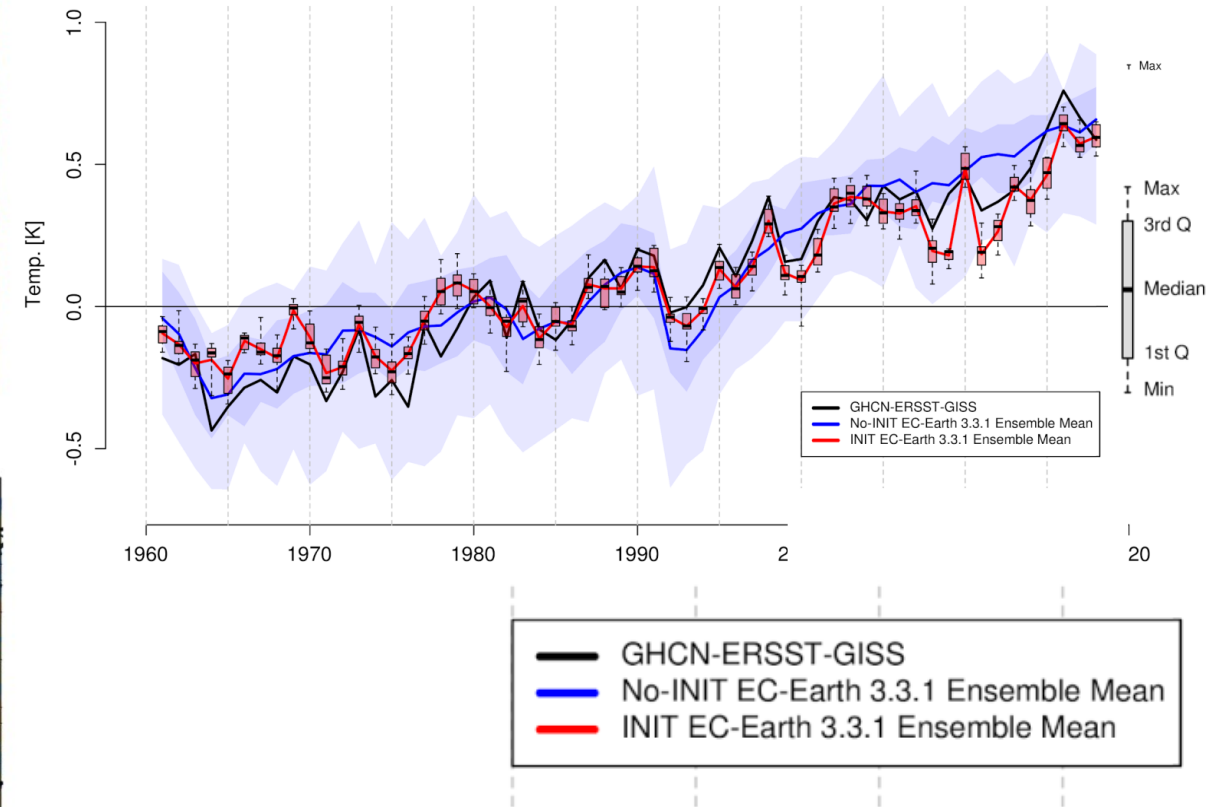
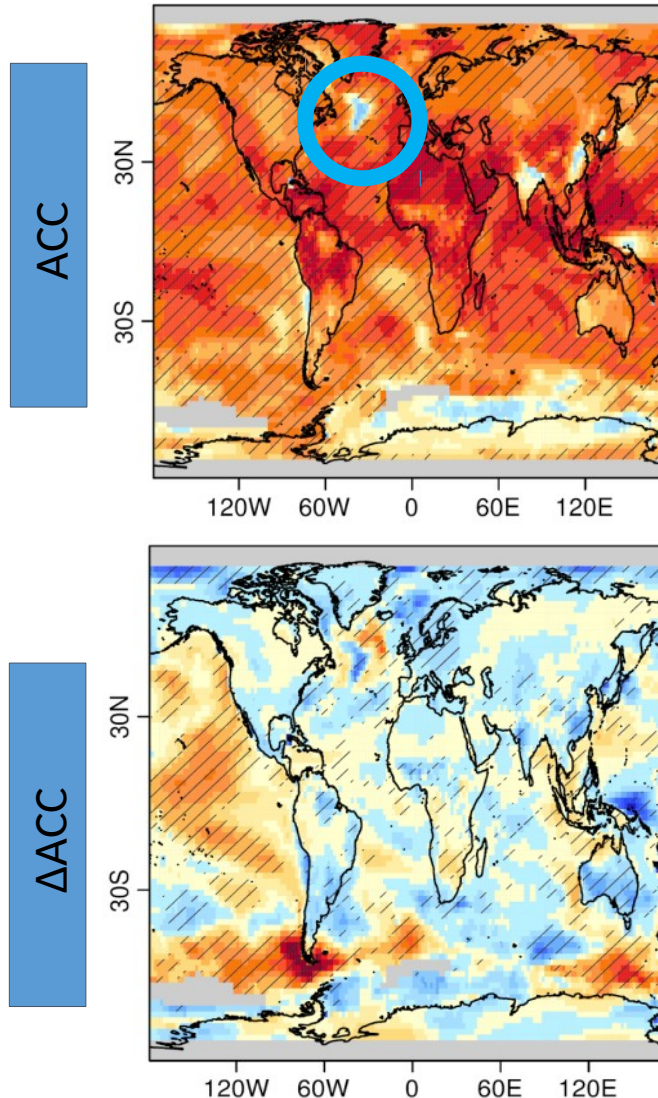
- 2m over land
- SST over ocean

INIT: 10 members

No-Init: 15 members

Hatching: significant (95%) correlation / difference

Year 1= Month 3 - 14



Added value over some ocean regions.
No added value over land.

Skill Assessment - Surface Temperature - Multiple Years

Anomaly Correlation
Coefficient

Combined
surface temperature:

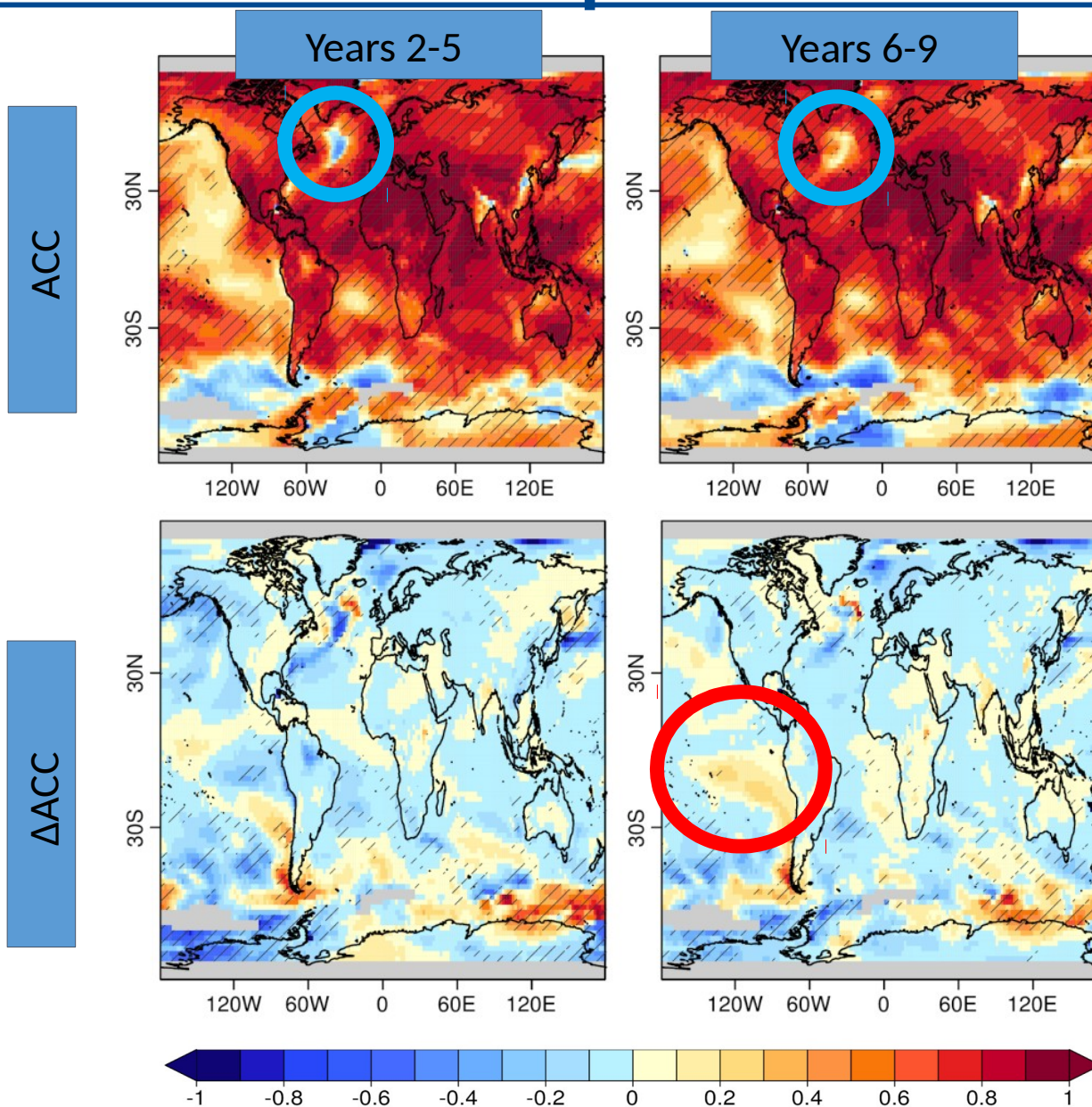
- 2m over land
- SST over ocean

INIT: 10 members

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Hatching: significant (95%)
correlation / difference

Year 1= Month 3 - 14

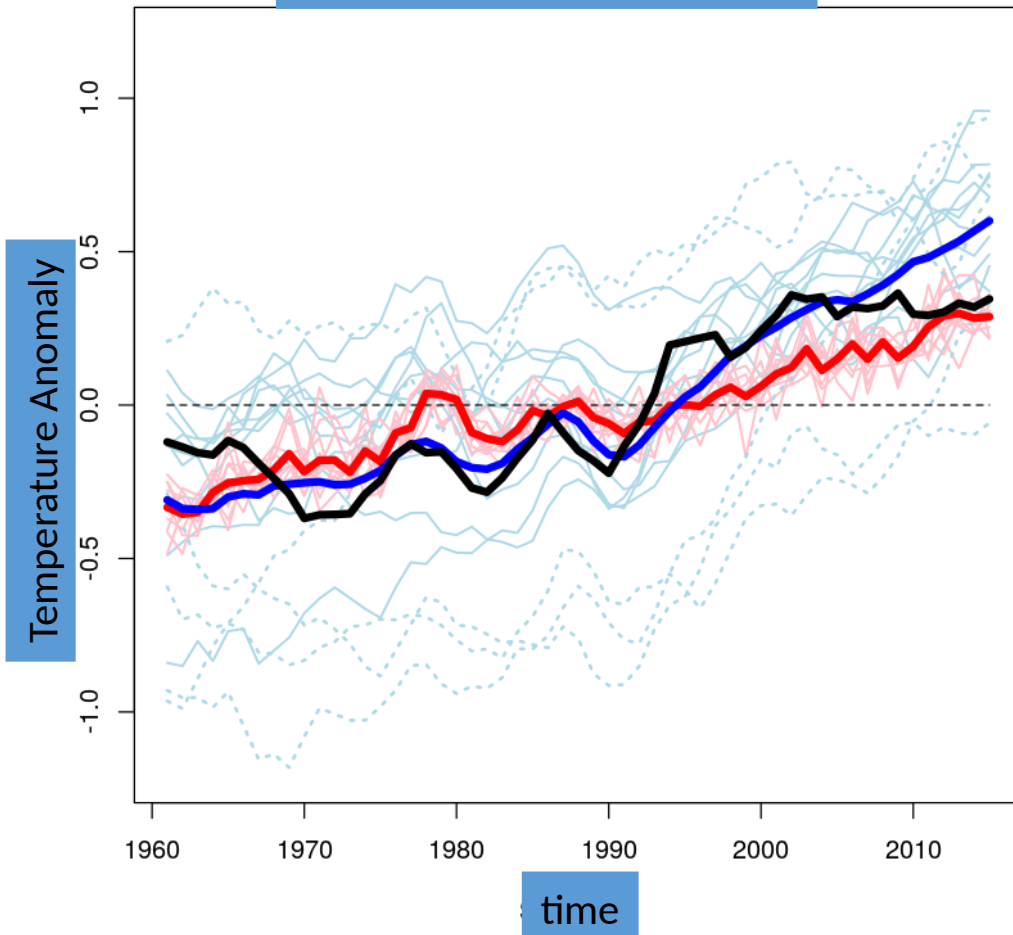


Benefit of initialization
over ENSO region in later
Forecast years.

Added value depends on reference

Un-initialized runs show wide range of behavior;
skill estimates depend on how the ensemble is constructed

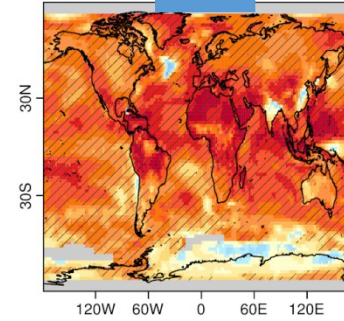
SST North Atlantic (yr 2-5)



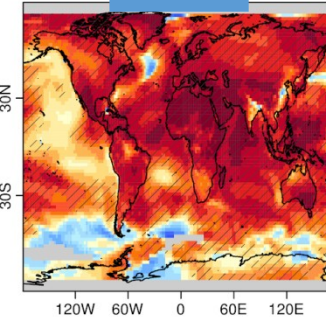
ΔACC
(10 "worst")

ΔACC
(10 "best")

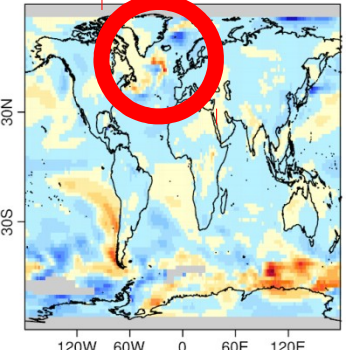
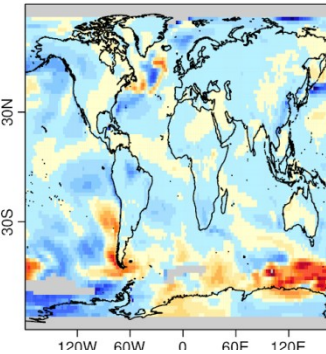
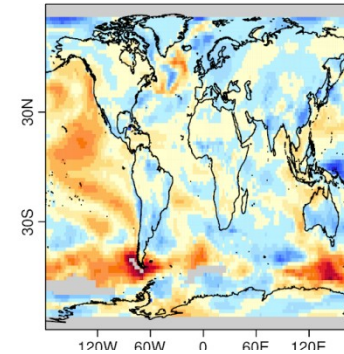
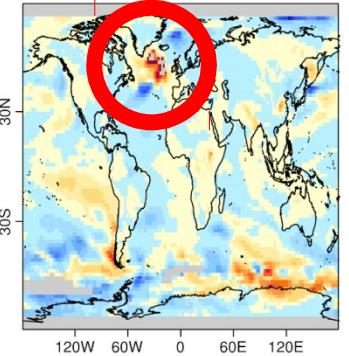
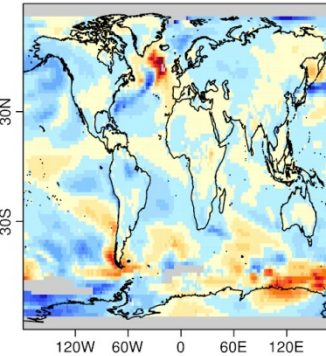
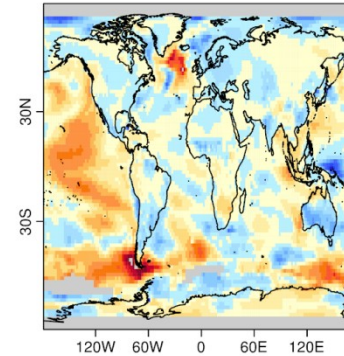
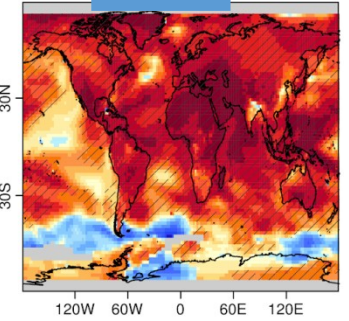
Yr1



Yr2-5



Yr6-9

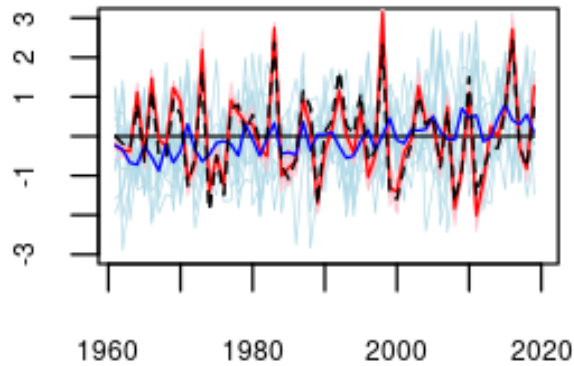


Skill Assessment – Ocean Indices

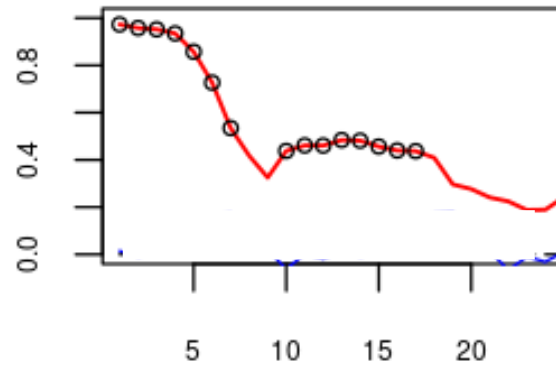
ACC: Anomaly Correlation Coefficient

MSSS: Mean Squared (Error) Skill Score

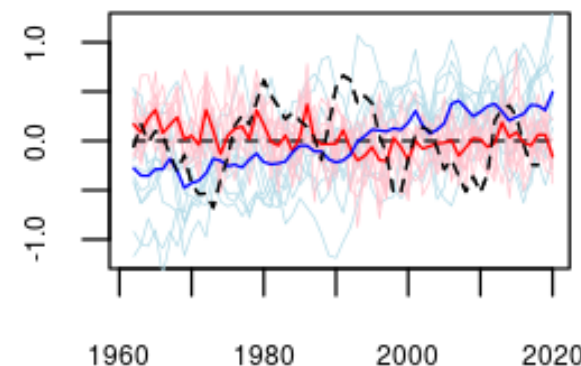
Nino 3.4, 1st DJF



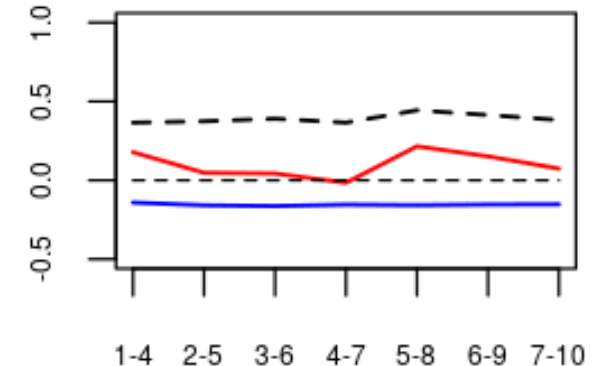
Nino 3.4, ACC



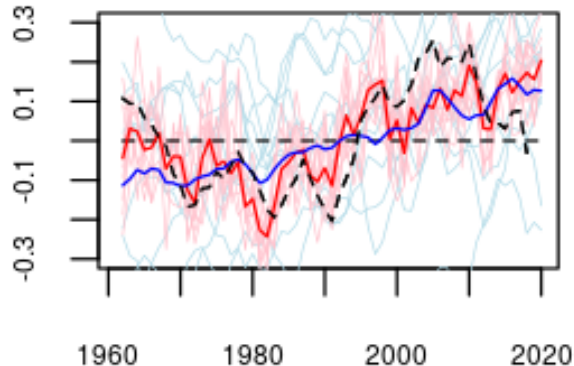
IPO, Years 2-5



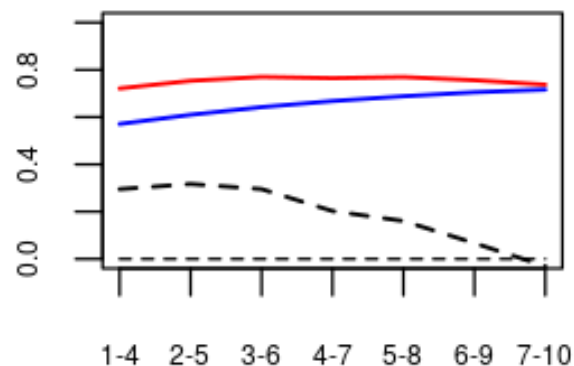
IPO, ACC and MSSS



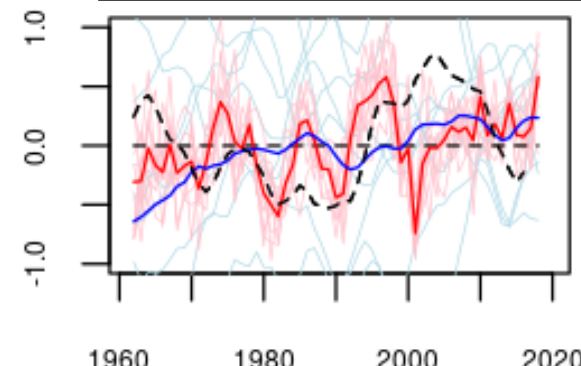
AMV, Years 2-5



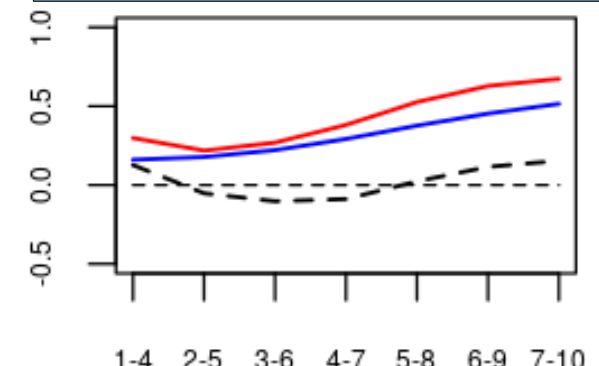
AMV, ACC and MSSS



SPG OHC300, Years 2-5



SPG OHC300, ACC and MSSS



— No-INIT EC-Earth 3.3.1 Ensemble Mean
— INIT EC-Earth 3.3.1 Ensemble Mean
- - - HadISST

AMV: Atlantic Multidecadal Variability

IPO: Interdecadal Pacific Oscillation

SPG OHC: North Atlantic Subpolar Gyre Ocean Heat Content

Conditional Bias

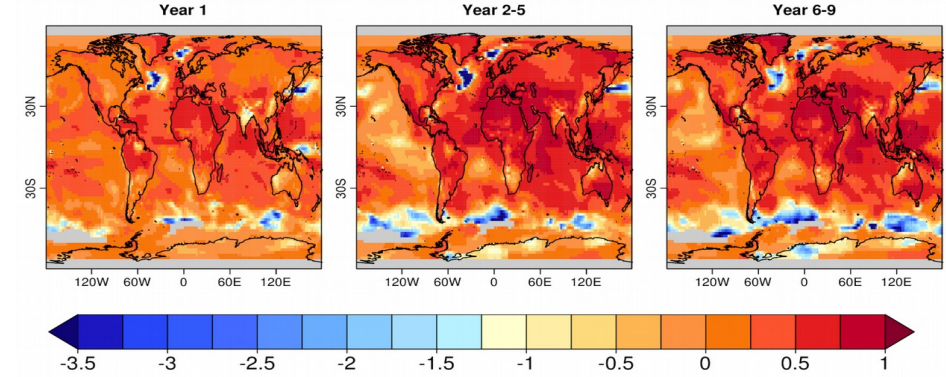
Forecast accuracy: Mean Squared (error) Skill Score (MSSS)

$$\text{MSSS}(H, \bar{O}, O) = r_{HO}^2 - \left[r_{HO} - \frac{S_H}{S_O} \right]^2 - \left[\frac{\bar{H} - \bar{O}}{S_O} \right]^2$$

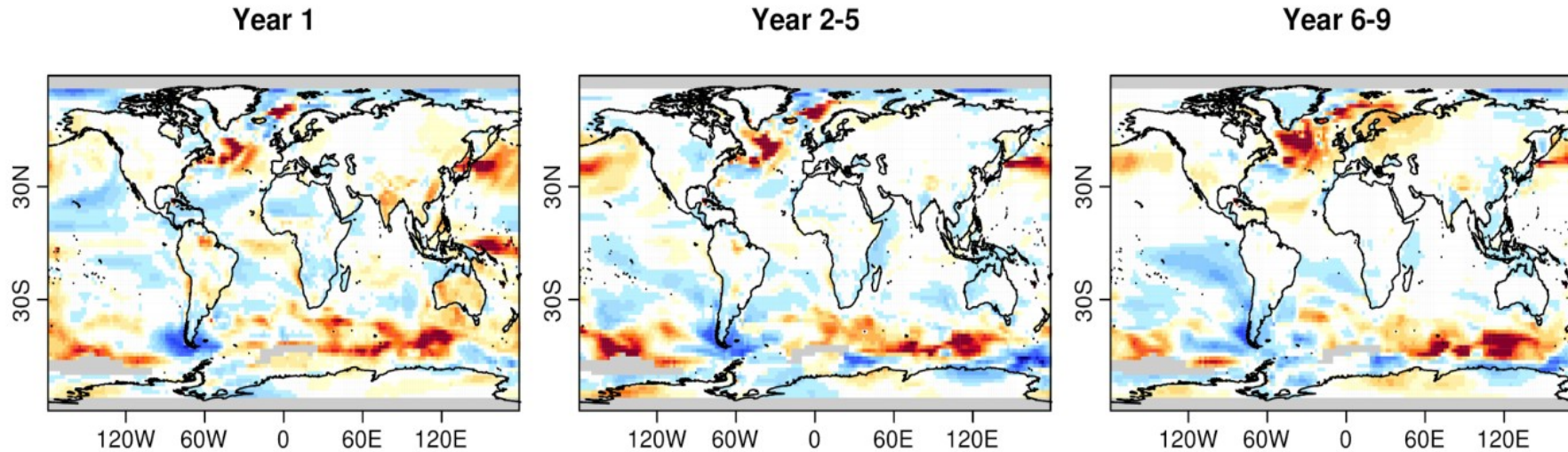
r_{HO} : sample correlation between the hindcasts and the observations

S_H^2 ; S_O^2 : the sample variances of the ensemble mean hindcasts and observations,

$\bar{O} = \sum_{j=1}^n O_j$: climatological forecast (where O_j represents the observations, or perfect-model reference respectively, over $j = 1, \dots, n$ start times), \bar{H} the mean hindcast



Difference Init minus No-Init of conditional bias (absolute values)



Greater Cond. Bias in No-Init

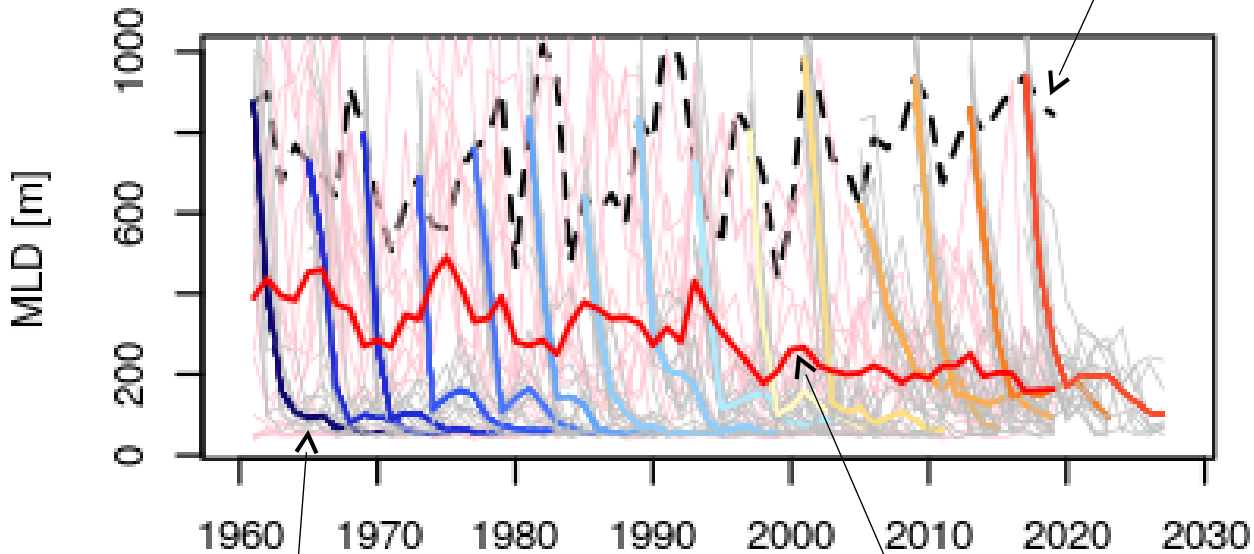


Greater Cond. Bias in Init

Model Drift in North Atlantic

Mixed Layer Depth,
Labrador Sea, March-April

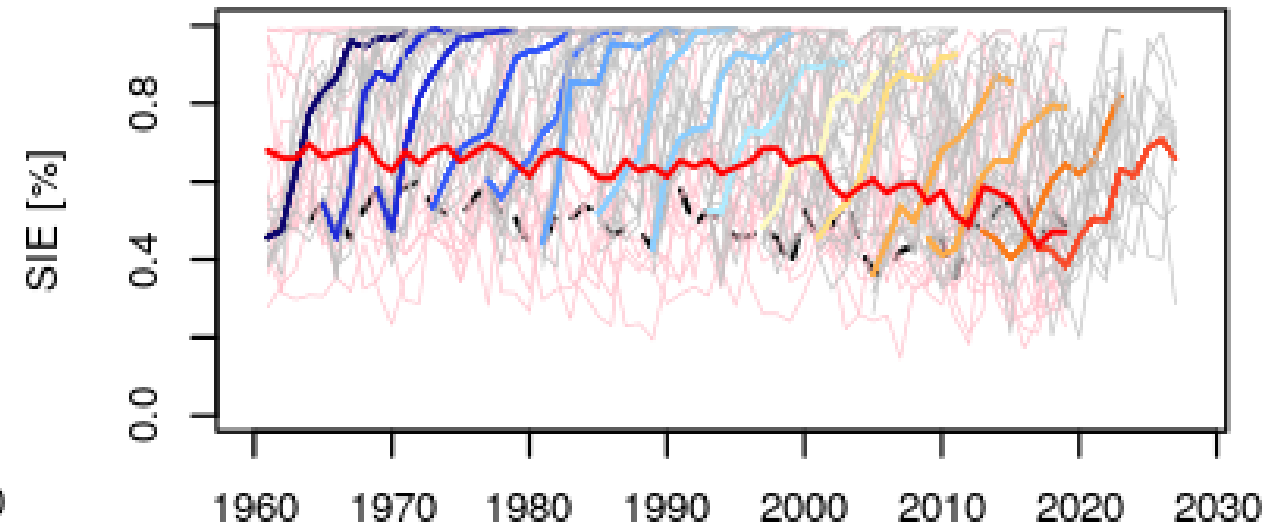
Initial state
(black dotted line)



INIT Ensemble Mean
every 4th start date
(dark blue to dark red lines)

NO-INIT
(red line)

Sea Ice Extent,
Labrador Sea, March-April

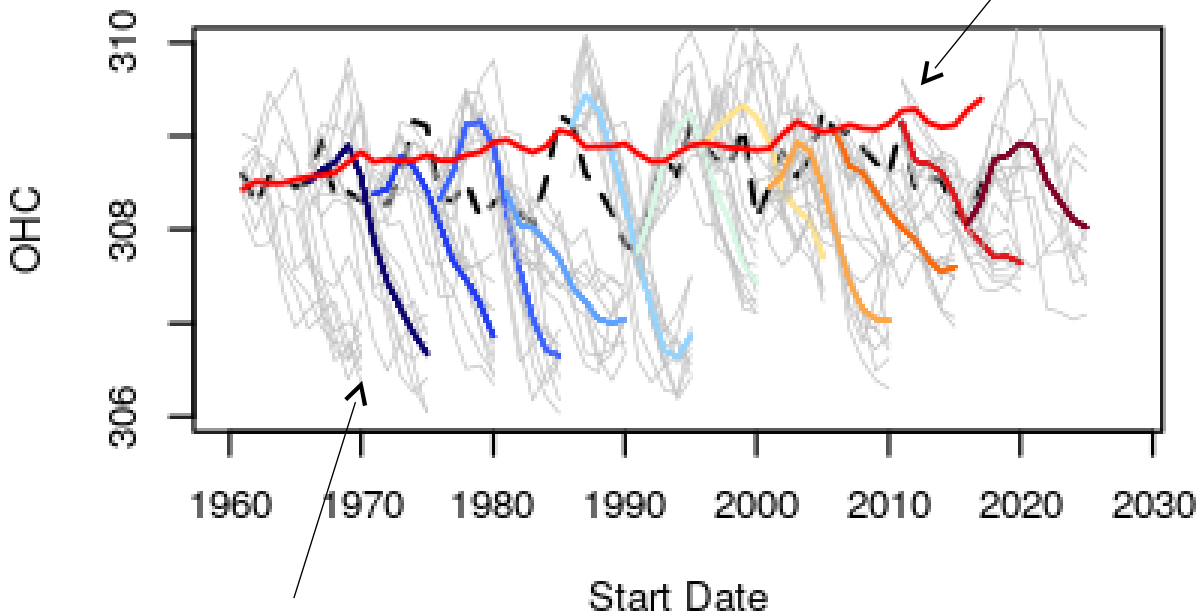


INIT does not drift towards NO-INIT

Model Drift in the North Atlantic

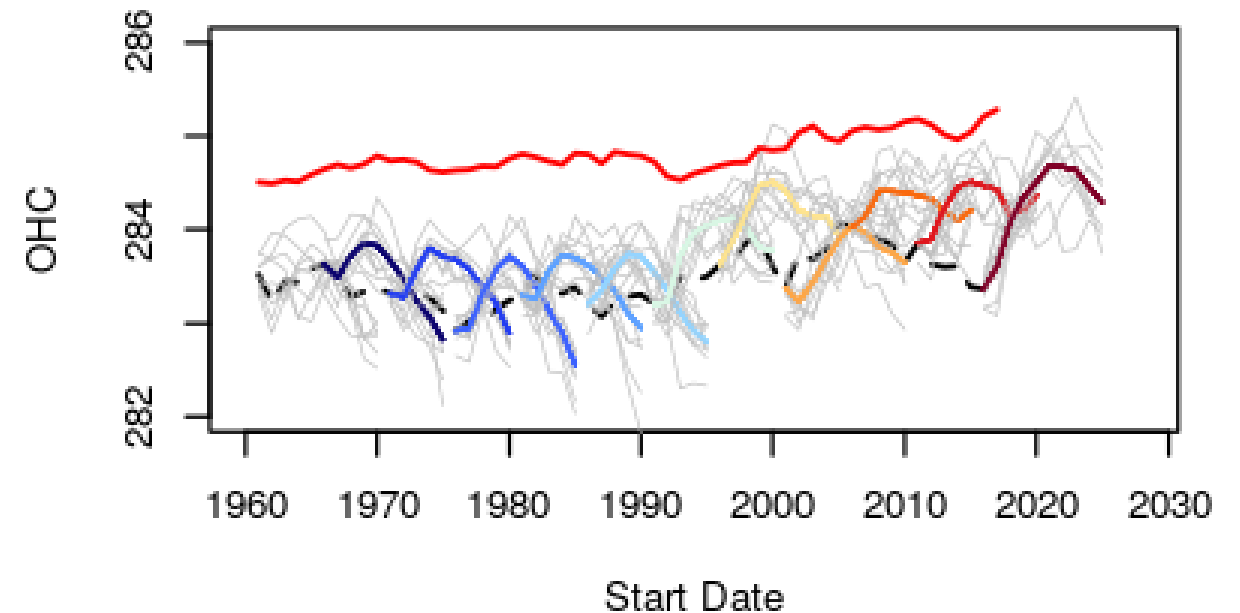
Western Subpolar Gyre,
OHC 300, March-April

NO-INIT
(red line)



INIT Ensemble Mean
(dark blue to dark red lines)

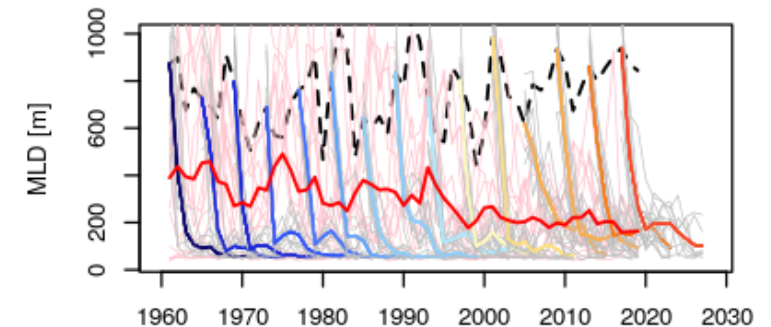
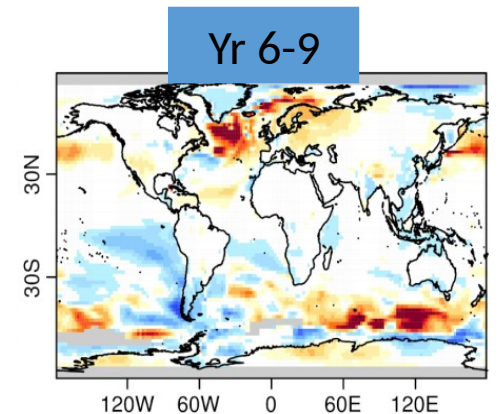
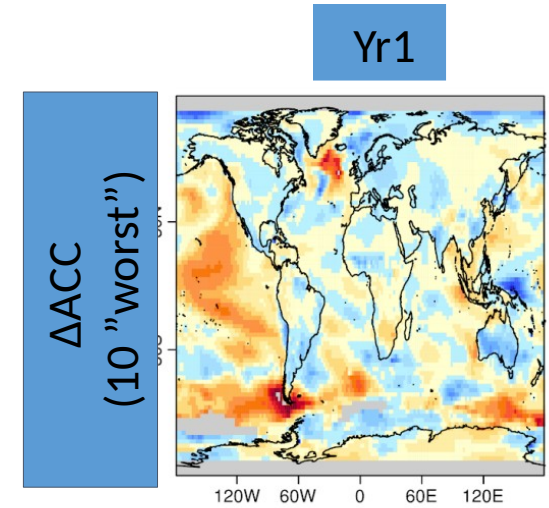
Eastern Subpolar Gyre,
OHC 300, March-April



- Initial tendency to a warmer state.
- Tendency is disrupted, followed by fast cooling.
- This disruption occurs first in the Western SPG.

Summary

- Surface temperature skill in EC Earth 3 DCP-P-A hindcasts:
 - initialization-related skill over some ocean regions in in forecast year 1
 - added value of initialization decreases beyond forecast year 1
 - higher skill of initialized runs over ENSO region in later forecast years
- Identifying added value from initialization is sensitive to the behaviour of non-initialized ensemble used for reference
- Initialization leads to smaller conditional bias over Pacific and greater conditional bias over North Atlantic
- Hindcasts do not appear to drift towards non-initialized ensemble in upper ocean in the North Atlantic





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Thank you!

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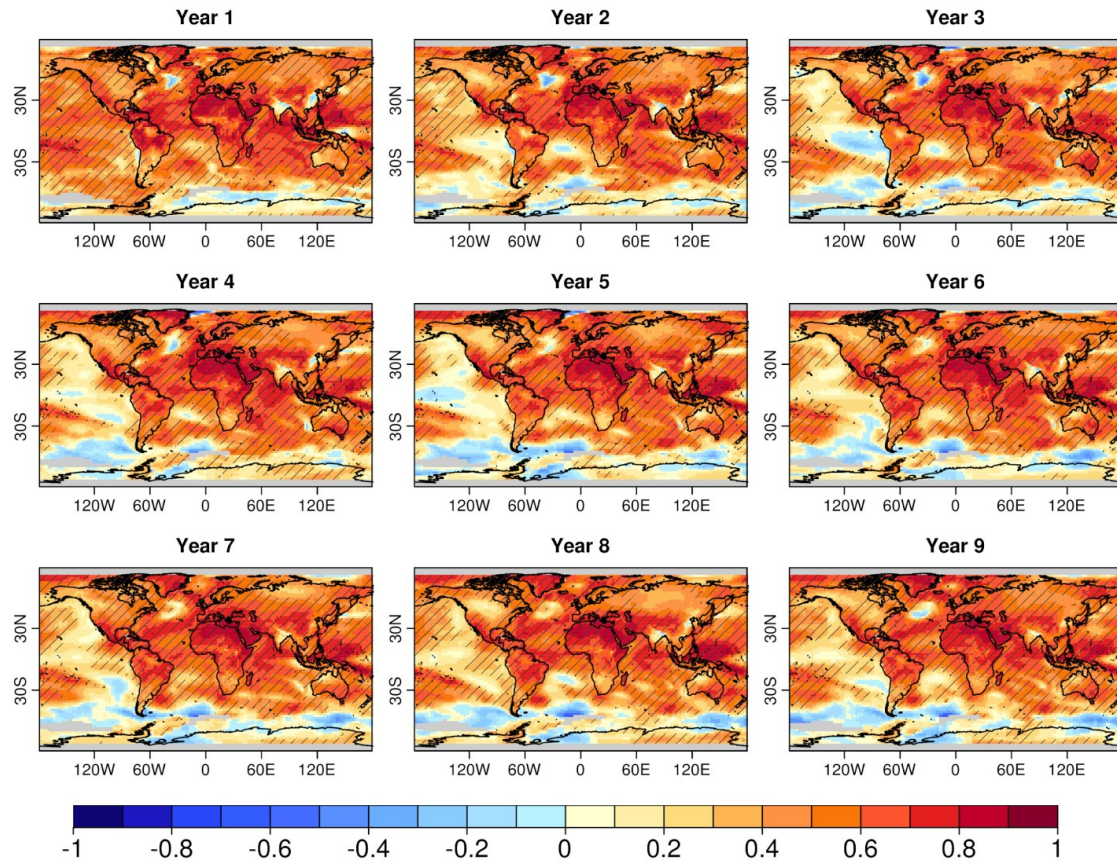
STARS
POST-DOCTORAL PROGRAM



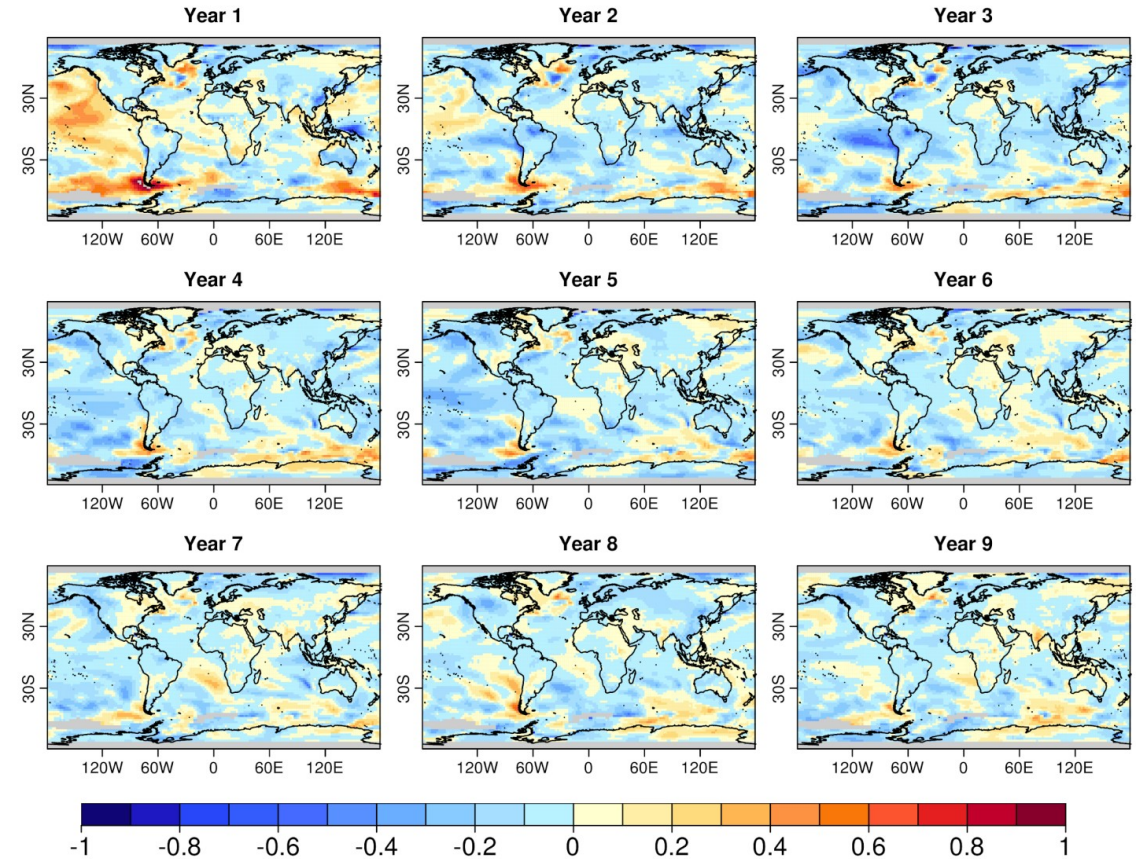
EUCP
European Climate Prediction system

ACC for individual forecast years

ACC Init

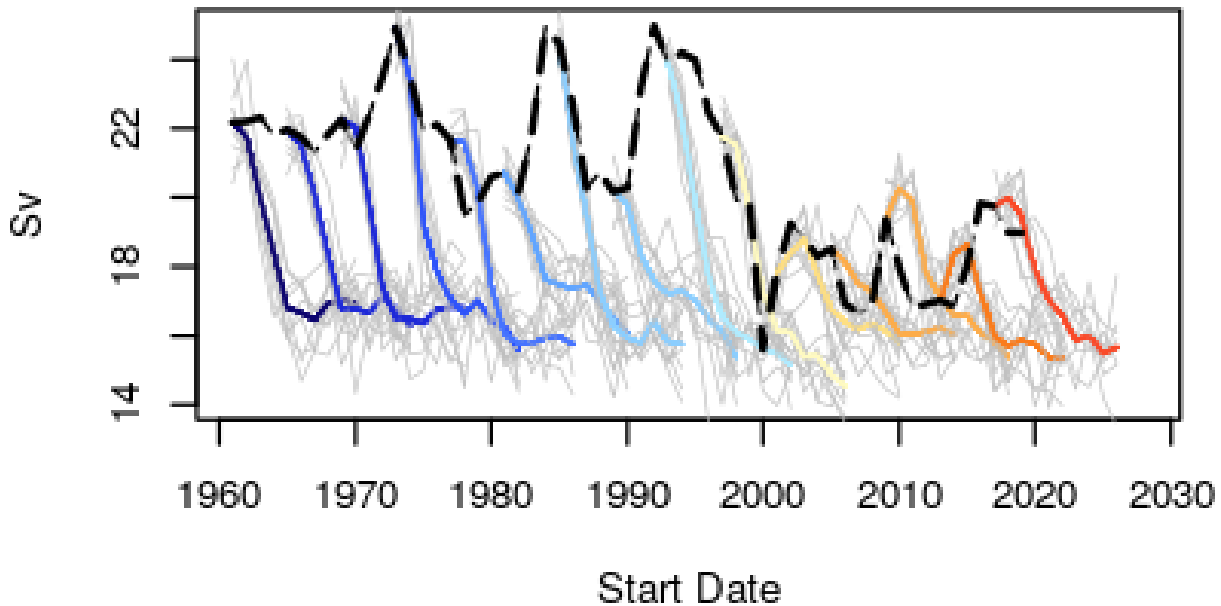


Difference Init minus No-Init



Model Drift in North Atlantic

AMOC at 45° N



AMOC at 45° N
Climatology for different start dates

